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(54) **METHOD OF MANUFACTURING LIGHT EMITTING DEVICE PACKAGE**

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H01L 33/00	(2010.01)
H01L 23/00	(2006.01)
G01R 31/26	(2014.01)

(52) **U.S. Cl.**

CPC ***H01L 33/005*** (2013.01); ***G01R 31/2635*** (2013.01); ***H01L 24/97*** (2013.01); *H01L 2224/14* (2013.01); *H01L 2224/16225* (2013.01); *H01L 2933/0041* (2013.01)

(58) **Field of Classification Search**

CPC H01L 33/0095

See application file for complete search history.

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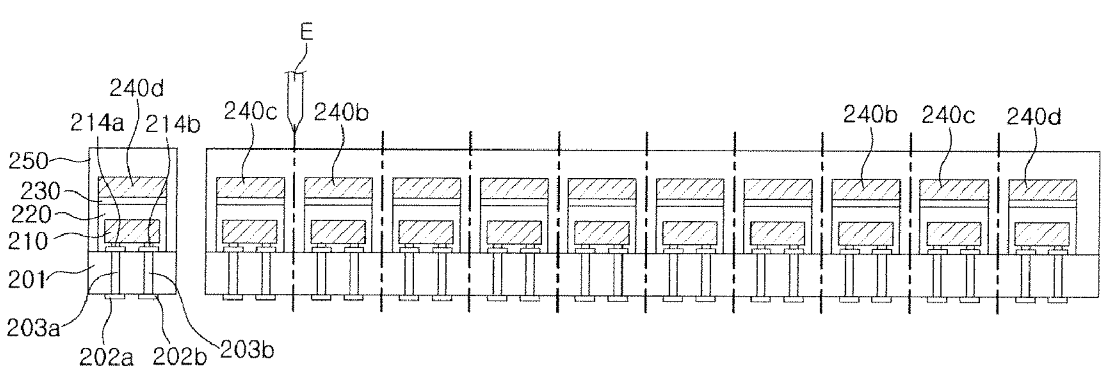
(57) **ABSTRACT**

A method of manufacturing a light emitting device package includes forming a plurality of light emitting devices by growing a plurality of semiconductor layers on a wafer, and measuring color characteristics of light emitted from each of the plurality of light emitting devices. For each of the plurality of light emitting devices, a type and an amount of wavelength conversion material is determined for color compensating the light emitting device based on a difference between the measured color characteristics and target color characteristics. A wavelength conversion layer is formed on at least two light emitting devices among the plurality of light emitting devices, the wavelength conversion layer having the type and the amount of wavelength conversion material determined for the at least two light emitting devices. The plurality of light emitting devices is then divided into individual light emitting device packages.

17 Claims, 17 Drawing Sheets



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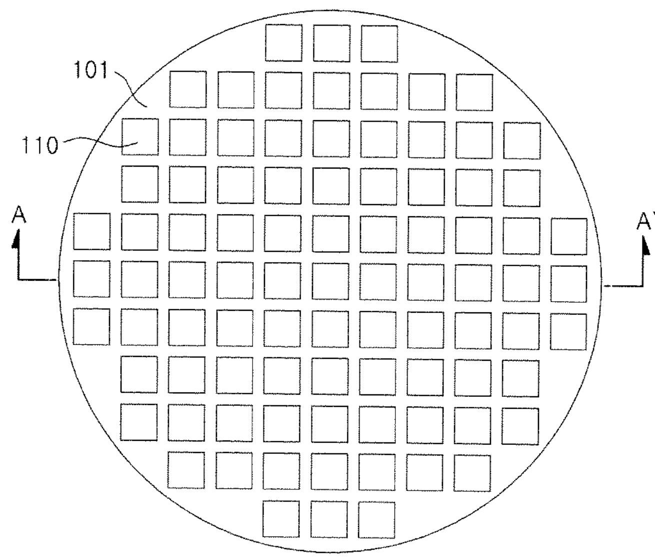


FIG. 1A

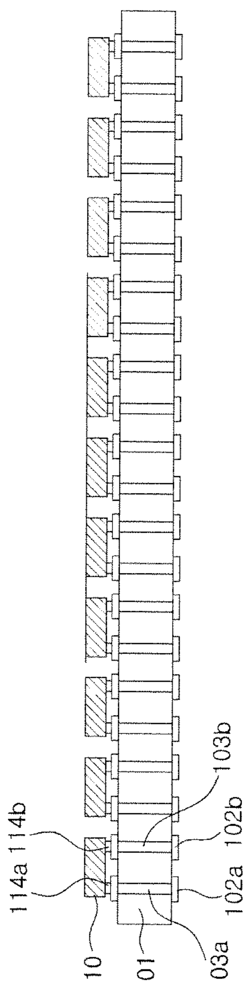


FIG. 1B

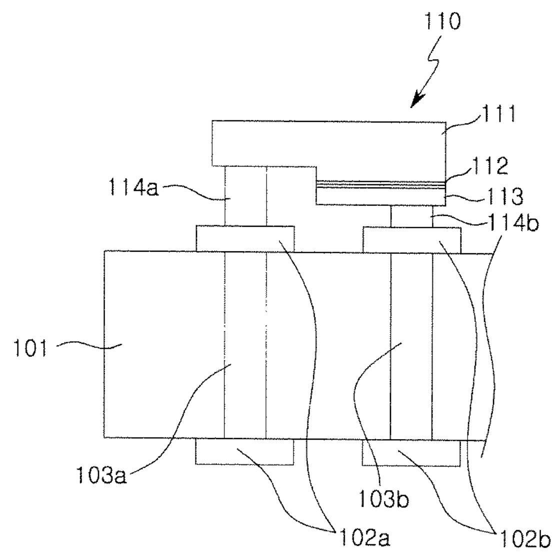


FIG. 1C

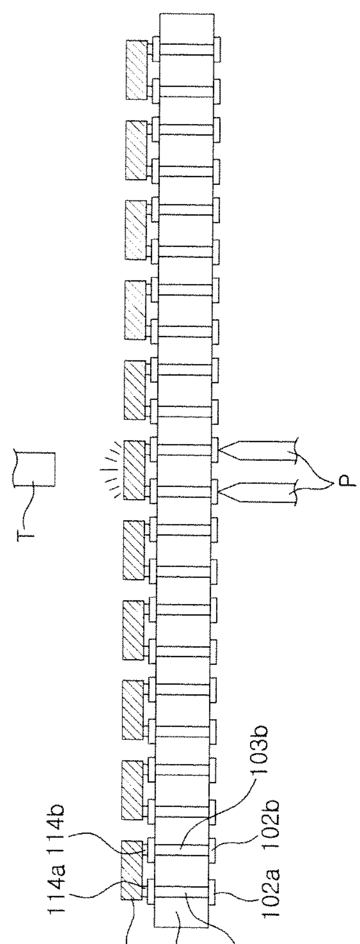


FIG. 2A

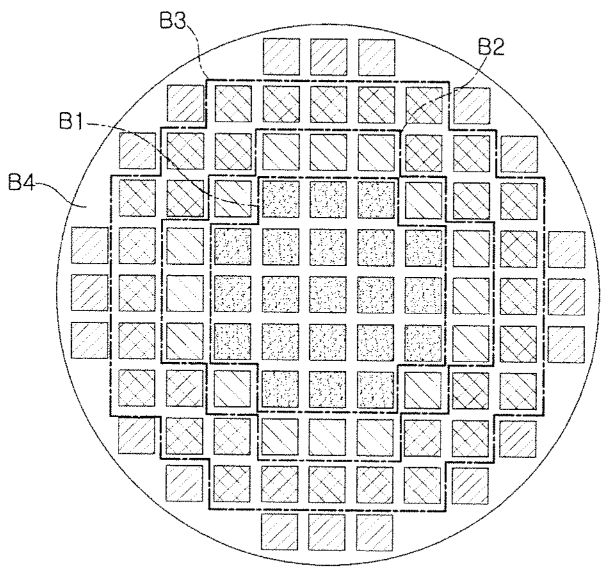


FIG. 2B

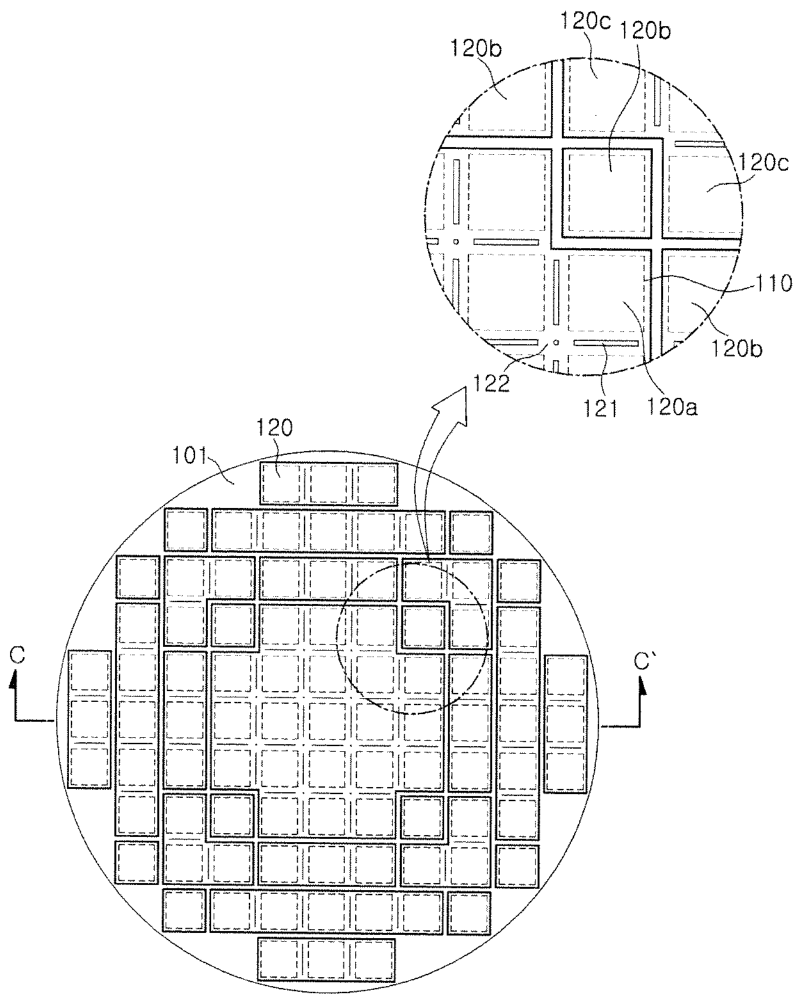
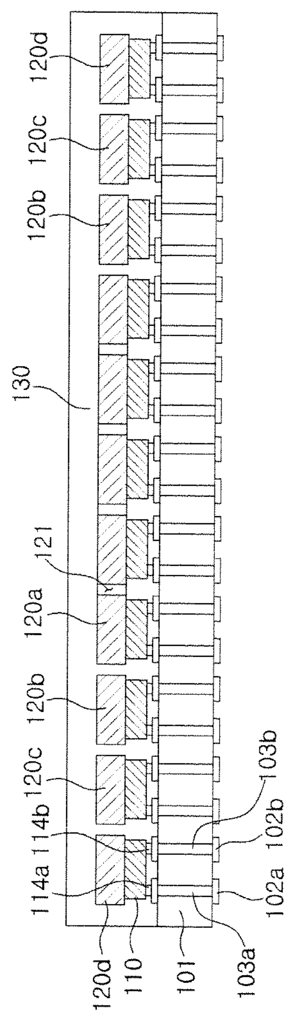


FIG. 3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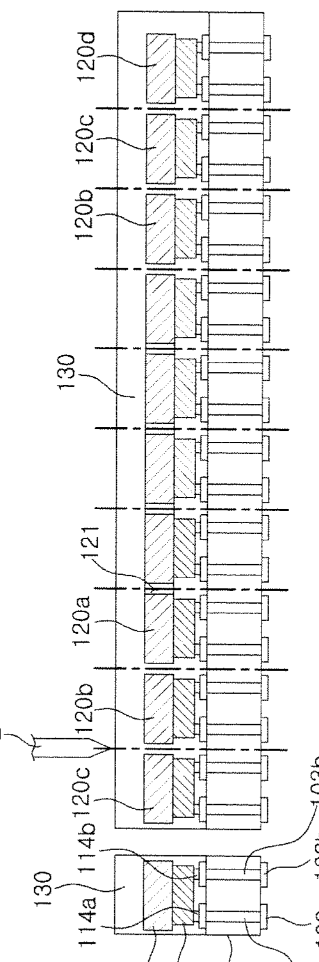
120c
120b
130
121
120a
120b
120c
114a
114b
103b
102b
102a
120d
110
101
103a

FIG. 4



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120c
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114a
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102b
102a
120d
110
101
103a

FIG. 5

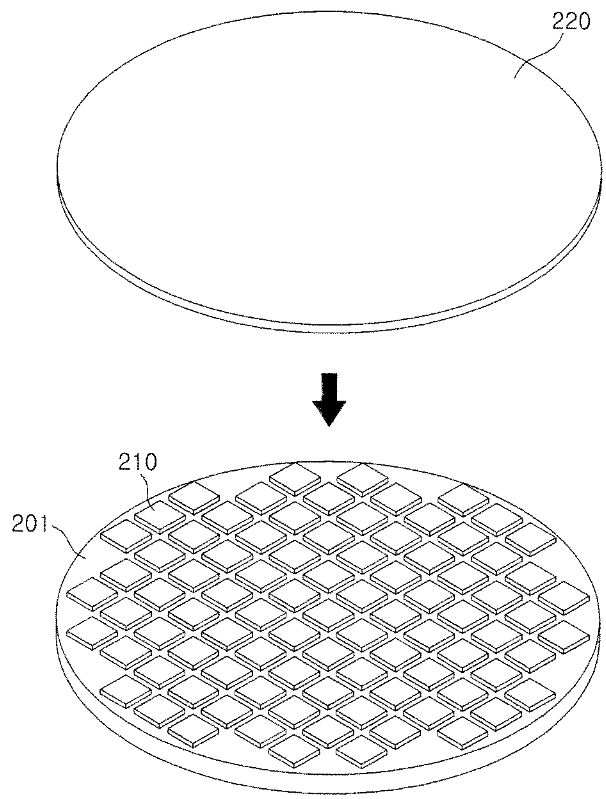


FIG. 6

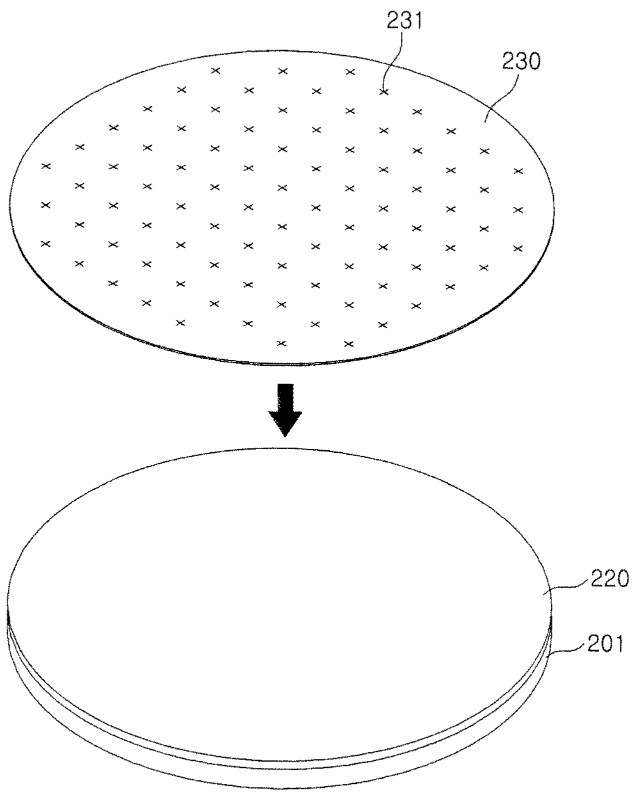


FIG. 7

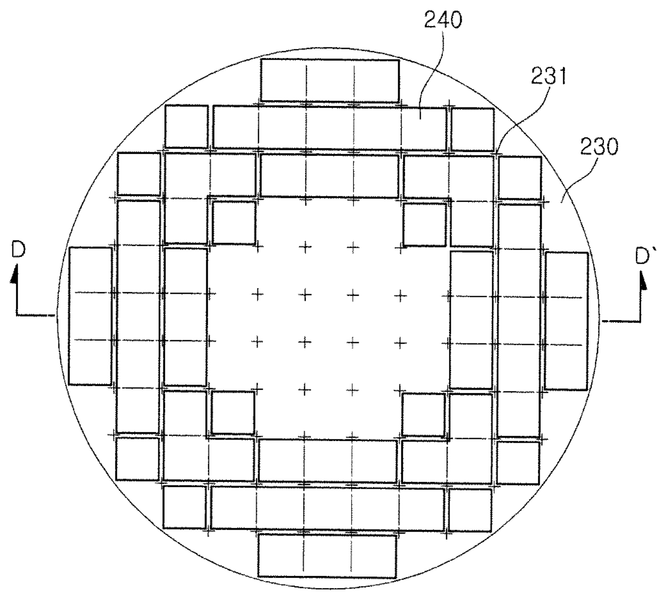
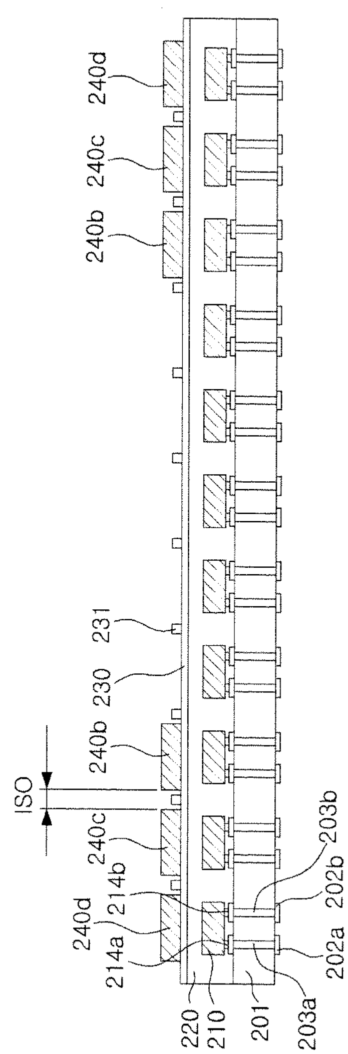


FIG. 8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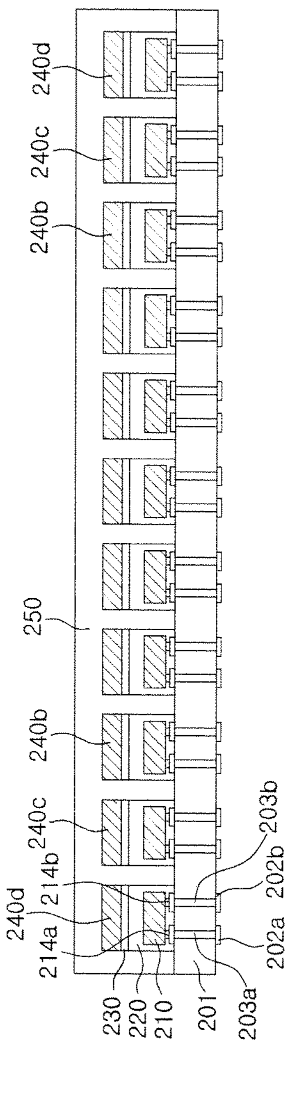
201
203a

FIG. 9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240d
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203b
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202a
203a
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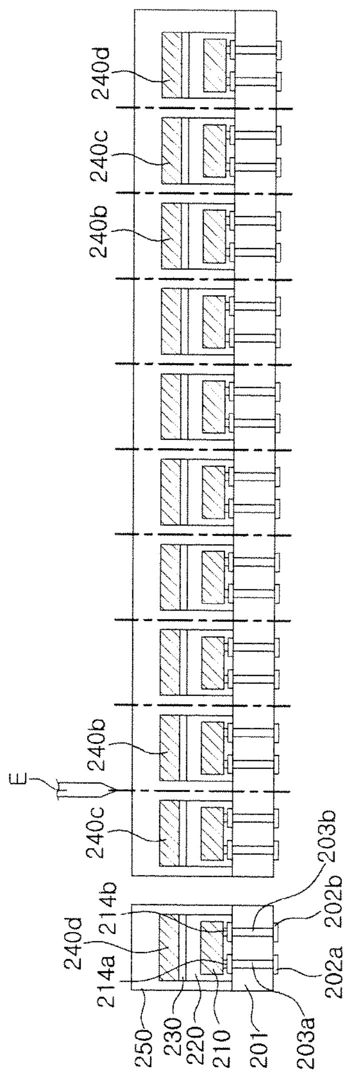
220
210
201

FIG. 10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240c
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240b
E
240c
240d
214a
214b
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220
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201
203a
202a
202b
203b

FIG. 11

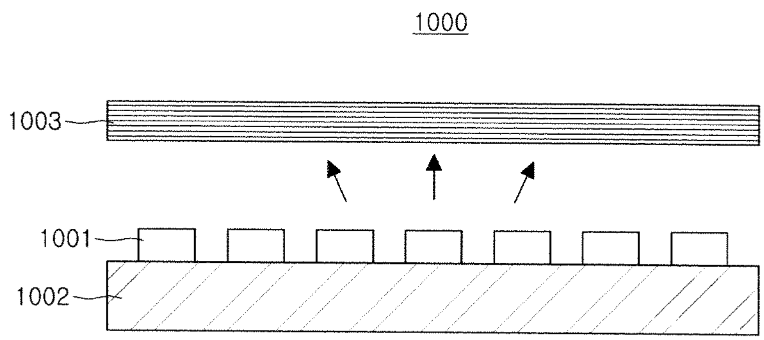


FIG. 12

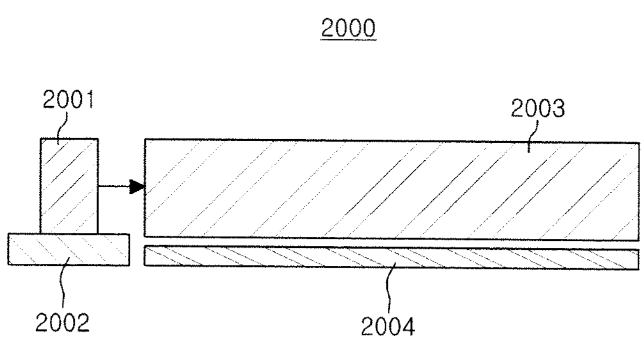


FIG. 13

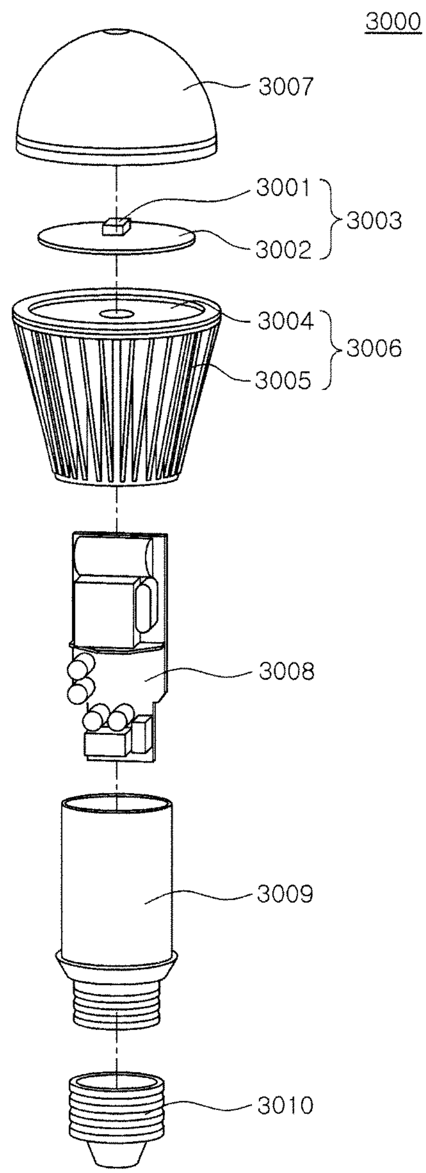
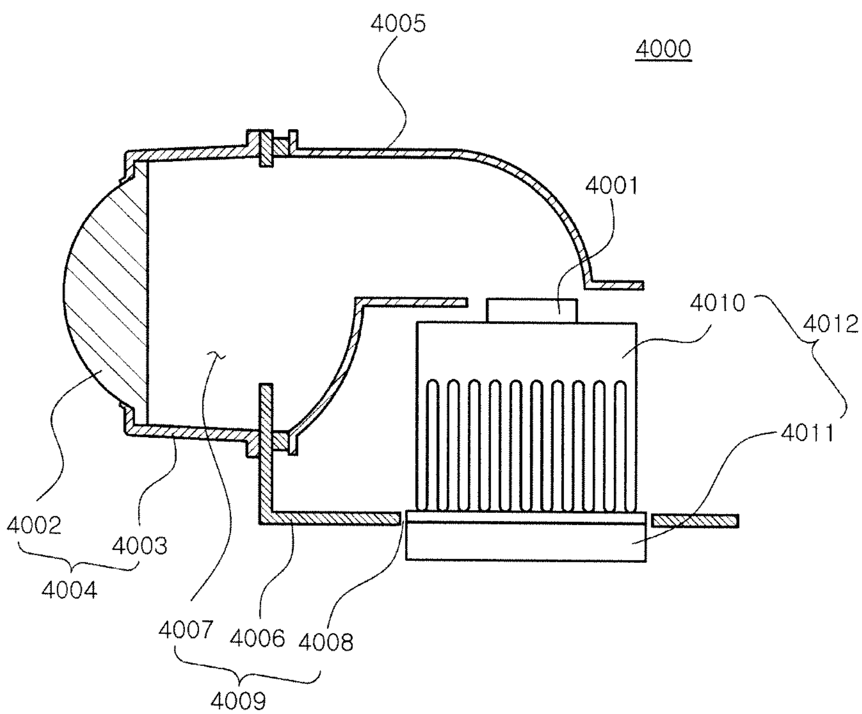


FIG. 14



4005
4000
4001
4010
4012
4011
4002
4003
4004
4007
4006
4008
4009

FIG. 15

METHOD OF MANUFACTURING LIGHT EMITTING DEVICE PACKAGE

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of Korean Patent Application No. 10-2014-0070036 filed on Jun. 10, 2014, with the Korean Intellectual Property Office, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

The present disclosure relates to a method of manufacturing a light emitting device package.

BACKGROUND

A light emitting diode (LED) is a device including a material that emits light through the application of electrical energy thereto, in which energy generated by electron-hole recombination in semiconductor junction parts is converted into light to be emitted therefrom. LEDs are commonly employed as light sources in general lighting devices, display devices, and the like, and the development of LEDs has thus been accelerated.

In particular, recently, the development and employment of light emitting diodes (LEDs) (e.g., gallium nitride-based LEDs) has increased, and mobile device keypads, vehicle turn signal lamps, camera flashes, and the like, using such LEDs, have been commercialized, and in line with this, the development of general lighting devices using LEDs has been accelerated. Products in which LEDs are used, such as backlight units of large TVs, vehicle headlamps, general lighting devices, and the like, are gradually moving toward large-sized products having high outputs and high efficiency, and a range of LED use is further being expanded.

Accordingly, there is a need for a method of reducing manufacturing costs and shortening manufacturing time for mass production of LED packages.

SUMMARY

An exemplary embodiment in the present disclosure may provide a method of reducing manufacturing costs and shortening manufacturing time for mass production of LED packages.

According to an exemplary embodiment in the present disclosure, a method of manufacturing a light emitting device package may include forming a plurality of light emitting devices by growing a plurality of semiconductor layers on a wafer, and measuring color characteristics of light emitted from each of the plurality of light emitting devices. A type and an amount of wavelength conversion material for color compensating each of the plurality of light emitting devices is determined based on a difference between the measured color characteristics and target color characteristics. A wavelength conversion layer is formed on at least two light emitting devices among the plurality of light emitting devices to have the type and the amount of wavelength conversion material determined for the at least two light emitting devices. The plurality of light emitting devices is then divided into individual light emitting device packages.

The forming of the wavelength conversion layer may further include preparing a wavelength conversion film having the type and the amount of the wavelength conversion material determined for the at least two light emitting devices, cutting the wavelength conversion film to have an area sufficient to cover the at least two light emitting devices, and disposing the cut wavelength conversion film on the at least two light emitting devices.

The wavelength conversion film may be divided into a plurality of regions.

Areas of the plurality of regions may correspond to areas of the individual light emitting devices.

Perforations may be formed in the wavelength conversion film between the plurality of regions.

The perforations may be slits.

The method may further include cutting the plurality of light emitting devices into individual light emitting devices and mounting the plurality of light emitting devices on a package substrate, prior to forming the wavelength conversion layer. The dividing into the individual light emitting device packages may include dicing the package substrate.

The method may further include forming a light transmissive encapsulating part on the plurality of light emitting devices on which the wavelength conversion layer has been formed, prior to dividing the plurality of light emitting devices into the individual light emitting device packages.

The forming of the wavelength conversion layer may include disposing on at least two light emitting devices a wavelength conversion film having the type and the amount of the wavelength conversion material determined for the at least two light emitting devices, where perforations are formed in the wavelength conversion film. The forming of the encapsulating part may include injecting an insulating material for the encapsulating part into the perforations.

The wavelength conversion film may be formed of a semi-cured material containing a phosphor.

The measured color characteristics of light emitted from each of the plurality of light emitting devices may include at least one of wavelength, power, full width at half maximum (FWHM), and color coordinates of light emitted from each of the plurality of light emitting devices.

The wavelength conversion film may have a structure in which a plurality of layers is stacked.

Different layers of the plurality of layers in the wavelength conversion film may include different phosphors.

According to an exemplary embodiment in the present disclosure, a method of manufacturing a light emitting device package may include forming a plurality of light emitting devices by growing a plurality of semiconductor layers on a wafer, and measuring color characteristics of light emitted from each of the plurality of light emitting devices. A wavelength conversion layer having a uniform thickness is formed to cover all of the plurality of light emitting devices. A type and an amount of a wavelength conversion material for color compensating each of the light emitting devices is determined based on a difference between the measured color characteristics and target color characteristics. An additional wavelength conversion layer is selectively formed on the wavelength conversion layer in a position corresponding to at least some of the plurality of light emitting devices to have the type and the amount of wavelength conversion material determined for the at least some of the plurality of light emitting devices. The plurality of light emitting devices is then divided into individual light emitting device packages.

The selective forming of the additional wavelength conversion layer may include applying the additional wavelength conversion layer to at least two of the plurality of light emitting devices having the type and the amount of wavelength conversion material determined.

According to a further exemplary embodiment in the present disclosure, a method may include measuring, for each

of a plurality of light emitting devices mounted on a substrate, color characteristics of light emitted from the light emitting device. A group of adjacent light emitting devices having similar measured color characteristics is identified among the plurality of light emitting devices. For the group of adjacent light emitting devices, a type and an amount of wavelength conversion material for color compensating the light emitting devices is determined based on a difference between the measured color characteristics and target color characteristics. A wavelength conversion film having the type and the amount of wavelength conversion material determined for the group of light emitting devices is disposed across the group of adjacent light emitting devices.

The wavelength conversion film may span across regions of the substrate between the adjacent light emitting devices, and the wavelength conversion film may include perforations formed in the wavelength conversion film in the regions spanning between the adjacent light emitting devices.

The method may further include forming a light transmissive encapsulating part on the plurality of light emitting devices, where the forming of the light transmissive encapsulating part includes injecting an insulating material for the encapsulating part into the perforations.

The identifying may include identifying a first region of the substrate having a first group of adjacent light emitting devices disposed thereon having similar first measured color characteristics, and a second region of the substrate having a second group of adjacent light emitting devices disposed thereon having similar second measured color characteristics different from the first measured color characteristics. The determining may include determining first and second types and first and second amounts of wavelength conversion material for color compensating the light emitting devices of the first and second groups, respectively, based on differences between the measured color characteristics and target color characteristics. The disposing may include disposing, across the first region of the substrate having the first group of adjacent light emitting devices disposed thereon, a first wavelength conversion film having the first type and the first amount of wavelength conversion material determined for the first group of light emitting devices, and disposing, across the second region of the substrate having the second group of adjacent light emitting devices disposed thereon, a second wavelength conversion film having the second type and the second amount of wavelength conversion material determined for the second group of light emitting devices.

The method may further include forming a light transmissive encapsulating part on the plurality of light emitting devices and in regions between the light emitting devices of the first and second groups.

BRIEF DESCRIPTION OF DRAWINGS

The above and other aspects, features and advantages in the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIGS. **1**A-**1**C, **2**A-**2**B, and **3** through **5** are schematic views illustrating processes for manufacturing light emitting device packages according to an exemplary embodiment in the present disclosure;

FIGS. **6** through **11** are schematic views illustrating processes for manufacturing light emitting device packages according to another exemplary embodiment in the present disclosure;

FIGS. **12** and **13** illustrate examples of a backlight unit to which a light emitting device package according to an exemplary embodiment in the present disclosure is applied;

FIG. **14** illustrates an example of a lighting device to which a light emitting device package according to an exemplary embodiment in the present disclosure is applied; and

FIG. **15** illustrates an example of a headlamp to which alight emitting device package according to an exemplary embodiment in the present disclosure is applied.

DETAILED DESCRIPTION

Exemplary embodiments in the present disclosure will now be described in detail with reference to the accompanying drawings.

The disclosure may, however, be exemplified in many different forms and should not be construed as being limited to the specific embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art.

In the drawings, the shapes and dimensions of elements may be exaggerated for clarity, and the same reference numerals will be used throughout to designate the same or like elements.

FIGS. **1**A-**1**C, **2**A, **2**B, and **3** through **5** are schematic views illustrating processes for manufacturing light emitting device packages according to an exemplary embodiment in the present disclosure.

First, a plurality of light emitting devices **110** may be formed by growing a plurality of semiconductor layers on a wafer. The plurality of light emitting devices **110** may be disposed above a package substrate **101** at predetermined intervals, as illustrated in FIG. **1**A.

FIG. **1**B is a side cross-sectional view taken along line A-A of FIG. **1**A, and FIG. **1**C is an enlarged view of one light emitting device **110** of FIG. **1**B.

As illustrated in FIGS. **1**B and **1**C, first and second bonding pads **102***a* and **102***b* may be formed on one or two opposing surfaces of the package substrate **101**, and the light emitting devices **110** may be mounted on the first and second bonding pads **102***a* and **102***b*. First and second electrodes **114***a* and **114***b* of the light emitting devices **110** may be electrically connected to the first and second bonding pads **102***a* and **102***b* using a conductive adhesive such as solder bumps or the like.

Specifically, the light emitting devices **110** may be mounted above one surface of the package substrate **101**, and first and second through electrodes **103***a* and **103***b* may penetrate through the package substrate **101** from one surface of the package substrate **101** to the other opposing surface thereof in a thickness direction. The first and second bonding pads **102***a* and **102***b* may be disposed on one surface and the other opposing surface of the package substrate **101** to which both ends of the first and second through electrodes **103***a* and **103***b* are exposed, such that electrodes on both surfaces of the package substrate **101** may be electrically connected to each other. The package substrate **101** may be a substrate for manufacturing wafer level packages (WLPs) in which packages are completely formed on the wafer level. Both surfaces of such a substrate for WLPs may be flat, and thus the size of a package in which the light emitting device **110** is mounted may be reduced to be approximately equal to the size of the light emitting device **110**.

Here, the package substrate **101** may be a plate-like substrate. Specifically, a substrate formed of Si, sapphire, ZnO, GaAs, SiC, $MgAl_2O_4$, MgO, $LiAlO_2$, $LiGaO_2$, GaN or the like, may be used. In an exemplary embodiment, an Si substrate may be used.

However, a material for the package substrate **101** is not limited thereto. Considering heat dissipation properties and electrical connections of light emitting device packages **100**, the package substrate **101** may be formed of an organic resin material containing epoxy, triazine, silicone, polyimide, or the like, or another organic resin material. In order to improve the heat dissipation properties and light emitting efficiency, the package substrate **101** may be formed of a ceramic material having high heat resistance, superior thermal conductivity, high reflective efficiency, and the like. For example, Al_2O_3, AlN, or the like, may be used.

Besides the aforementioned substrate, a printed circuit board, a lead frame, or the like may be used for the package substrate **101** according to the present exemplary embodiment.

As illustrated in FIG. **1**C, the light emitting devices **110** may be mounted above the package substrate **101**, and may include a first conductivity-type semiconductor layer **111**, an active layer **112**, and a second conductivity-type semiconductor layer **113** sequentially stacked therein. The first and second conductivity-type semiconductor layers **111** and **113** may be n-type and p-type semiconductor layers, respectively, and may be formed of a nitride semiconductor. The present inventive concept is not limited thereto; however, according to the present exemplary embodiment, the first and second conductivity-type semiconductor layers **111** and **113** may be understood as referring to n-type and p-type semiconductor layers, respectively. The first and second conductivity-type semiconductor layers **111** and **113** may be formed of a material having a composition of $Al_xIn_yGa_{(1-x-y)}N$ (where $0 \le x < 1$, $0 \le y < 1$, and $0 \le x+y < 1$). For example, GaN, AlGaN, InGaN, or the like may be used therefor.

The active layer **112** may be a layer for emitting visible light having a wavelength of approximately 350 nm to 680 nm. The active layer **112** may be formed of undoped nitride semiconductor layers having a single-quantum-well (SQW) structure or a multi-quantum-well (MQW) structure. For example, the active layer **112** may have an MQW structure in which quantum barrier layers and quantum well layers having a composition of $Al_xIn_yGa_{(1-x-y)}N$ (where $0 \le x < 1$, $0 \le y < 1$, and $0 \le x+y < 1$) are alternately stacked, such that the active layer **112** may have a predetermined energy bandgap and emit light through the recombination of electrons and holes in quantum wells. In the case of the MQW structure, an InGaN/GaN structure may be used, for example. The first and second conductivity-type semiconductor layers **111** and **113** and the active layer **112** may be formed using a crystal growth process known in the art, such as metal organic chemical vapor deposition (MOCVD), molecular beam epitaxy (MBE), hydride vapor phase epitaxy (HYPE), or the like.

The light emitting device **110** may have the first and second electrodes **114***a* and **114***b* disposed in the same direction (e.g., extending from a same surface of the light emitting device **110**), which is an LED chip having a flip-chip type structure. In order to reduce crystalline defects during the growth of the semiconductor layers, a buffer layer may be further included.

The first and second electrodes **114***a* and **114***b* may be provided to allow the first and second conductivity-type semiconductor layers **111** and **113** to be electrically connected to a power source, and may be connected via ohmic-contact to the first and second conductivity-type semiconductor layers **111** and **113**, respectively.

The first and second electrodes **114***a* and **114***b* may each have a single layer or multilayer structure formed of a conductive material having ohmic-contact with a respective one of the first and second conductivity-type semiconductor layers **111** and **113**. For example, the first and second electrodes **114***a* and **114***b* may be formed by depositing or sputtering at least one of gold (Au), silver (Ag), copper (Cu), zinc (Zn), aluminum (Al), indium (In), titanium (Ti), silicon (Si), germanium (Ge), tin (Sn), magnesium (Mg), tantalum (Ta), chromium (Cr), tungsten (W), ruthenium (Ru), rhodium (Rh), iridium (Ir), nickel (Ni), palladium (Pd), platinum (Pt), and a transparent conductive oxide (TCO). The first and second electrodes **114***a* and **114***b* may be disposed on and extend above the surface of the package substrate **101** on which the light emitting devices **110** are mounted.

Next (e.g., following the mounting of the light emitting devices **110** on the package substrate **101**), the color characteristics of the plurality of light emitting devices **110** may be measured.

As illustrated in FIG. **2**A, the color characteristics of the plurality of light emitting devices **110** may be measured using a method of measuring the characteristics of light emitted from the light emitting devices **110** when power is applied thereto.

In detail, the color characteristics may be measured by mounting each light emitting device **110** on a respective pair of the first and second bonding pads **102***a* and **102***b* of the package substrate **101**, applying power thereto using a probe P, and measuring the emitted light using a measuring device T. The color characteristics may be at least one of wavelength, power, full width at half maximum (FWHM), and color coordinates of light emitted from each light emitting device **110**. In the present exemplary embodiment, an average wavelength of light emitted from each light emitting device **110** may be measured.

However, the measuring method is not limited thereto. Various methods for measuring the color characteristics, such as a method of irradiating ultraviolet light or a laser beam onto the surfaces of the light emitting devices **110** and measuring light reflected from the surfaces, may be used.

In a case in which the color characteristics of the plurality of light emitting devices are measured by using the aforementioned method, some or all of the light emitting devices may frequently fail to exhibit uniform color characteristics. The growth of the plurality of light emitting devices may be different due to differences in temperature, supply gas flow, and the like, at different locations on a wafer during the manufacturing processes, even when the light emitting devices are manufactured on a same/single wafer. Accordingly, the light emitting devices differ in terms of a wavelength of light and/or an amount of light emitted, and the like.

However, in this case, not all the light emitting devices have different color characteristics. In general, adjacent light emitting devices have similar color characteristics according to regions based on the positions of the light emitting devices on the wafer during the manufacturing processes.

FIG. **2**B illustrates an example of measurement results (i.e., color characteristic values) of the color characteristics of the plurality of light emitting devices **110** manufactured on a single wafer. As illustrated, the light emitting devices **110** having similar color characteristics among the plurality of light emitting devices **110** are grouped within each one of regions B**1** to B**4**, and the regions B**1** to B**4** are distributed on the substrate **101** based on concentric circles. The plurality of light emitting devices **110** according to the present exemplary embodiment are distributed as illustrated in FIG. **2**B by way of example, but are not limited thereto. Specifically, the plurality of light emitting devices **110** produced on different wafers or during different manufacturing processes may have different distributions.

In a situation in which a same wavelength conversion layer is disposed on adjacent light emitting devices having similar color characteristics, manufacturing time may be significantly reduced, as compared with situations in which different wavelength conversion layers are disposed on each adjacent light emitting device. Therefore, according to the present exemplary embodiment, manufacturing time may be reduced by disposing a same wavelength conversion layer on multiple light emitting devices having the same or similar color characteristics, including on multiple adjacent light emitting devices having the same or similar color characteristics. For example, a first wavelength conversion layer (i.e., a wavelength conversion layer having a first type and a first set of characteristics) may be disposed on all light emitting devices in region B**1**, while second, third, and fourth wavelength conversion layers (i.e., wavelength conversion layers respectively having second, third, and fourth types and sets of characteristics different from the first type and set of characteristics and different from each other) may respectively be disposed on light emitting devices in regions B**2**, B**3**, and B**4**.

Next, a type and an amount of a wavelength conversion material required for color compensation of the light emitting devices **110** may be determined based on a difference between the previously measured color characteristics and color characteristics targeted in the manufacturing process (hereinafter, referred to as "target color characteristics").

In order to determine the type and the amount of the wavelength conversion material required for the color compensation of the light emitting devices **110**, it may be determined whether or not the previously measured color characteristics correspond to the target color characteristics. In a case in which the previously measured color characteristics conform to the target color characteristics, it may be determined that a wavelength conversion film in a standard amount for converting the light emitted from the light emitting devices **110** into white light is to be disposed on the light emitting devices **110**.

On the other hand, in a case in which the previously measured color characteristics do not conform to the target color characteristics, an amount of wavelength conversion film may be increased or decreased, so that the light emitted from the light emitting devices **110** is converted into light having target color characteristics after passing through the wavelength conversion film.

The amount of wavelength conversion film may be determined by quantifying a rate of change of color characteristics with respect to the amount of the wavelength conversion film and calculating the amount of wavelength conversion film required based on the change rate of the color characteristics.

For example, in a case in which a wavelength of light measured is relatively short with respect to the target color characteristics, an amount of wavelength conversion film capable of increasing wavelength may be increased so as to convert the light emitted from the light emitting devices **110** into longer wavelength light. In a contrary case in which a wavelength of light measured is relatively long with respect to the target color characteristics, an amount of wavelength conversion film capable of decreasing wavelength may be relatively increased, whereby the amount of wavelength conversion film suitable for the target color characteristics may be determined.

Next, as illustrated in FIG. **3**, a wavelength conversion layer **120** may be formed to cover at least two light emitting devices having the same or similar color characteristic values (e.g., color characteristic values classified within a same one of regions B**1** to B**4**) among the plurality of light emitting devices **110**, on the basis of the type and the amount of the wavelength conversion material determined as described above.

The forming of the wavelength conversion layer **120** may include preparing a wavelength conversion film, cutting the wavelength conversion film to have an area for covering at least two light emitting devices having the same color characteristic values (e.g., having color characteristic values classified in a same grouping region such as one of regions B**1**-B**4**), and disposing the cut wavelength conversion film on the at least two light emitting devices having the same color characteristic values.

The preparation of the wavelength conversion film may include processing a band-like wavelength conversion sheet wound around a roll, the wavelength conversion sheet having a uniform width and a uniform thickness.

The wavelength conversion sheet may be in a partially cured state at room temperature. A semi-cured (b-stage) wavelength conversion film, changeable in shape through a pressing process or the like, may be used.

Here, the wavelength conversion sheet may be a film including at least one wavelength conversion material, such as a phosphor, a quantum dot, or the like, dispersed in semi-cured silicone.

Here, the wavelength conversion sheet may have a structure in which one or more layers are stacked, and the layers may include different phosphors or quantum dots.

Individual wavelength conversion layers **120*a***, **120*b***, **120*c***, and **120*d*** may be prepared by cutting the wavelength conversion sheets according to the previously determined amount and/or region patterns. Since the wavelength conversion sheet has the form of a band having a uniform width and a uniform thickness, when a roller provided with an embossed pattern is rolled on the surface of the wavelength conversion sheet while pressure is applied thereto, such an embossed pattern may be engraved on the wavelength conversion film, thereby forming perforations in the wavelength conversion film. However, a method of forming perforations is not limited thereto, and the perforations may be formed by various methods such as a method of irradiating a laser beam onto the surface of the wavelength conversion film.

As illustrated in FIG. **3**, the perforations formed in the wavelength conversion film may have the form of slits **121** and holes **122**. Specifically, the perforations may be disposed to divide the wavelength conversion film into areas for covering the individual light emitting devices **110**. The perforations may be formed to be positioned between the light emitting devices **110** at the time of disposing the wavelength conversion layer **120** on the devices **110** in a subsequent process.

Each slit **121** may be formed in a region between two light emitting devices **110** that are adjacent to each other, and the hole **122** may be formed in a region in which four light emitting devices **110** are adjacent to each other. Sizes of the slit **121** and the hole **122** may be adjusted to allow the slit **121** and the hole **122** to be disposed between the individual light emitting devices **110** while allowing a liquid insulating material to be injected thereinto, whereby the insulating material may be easily injected in a subsequent process for forming an encapsulating part. In addition, multiple slits **121** and holes **122** may be provided in each region.

The use of perforations such as the slits **121** and the holes **122** may prevent the formation of voids in the encapsulating part in situations in which the liquid insulating material is not injected between the individual light emitting devices **110** during forming the encapsulating part after disposing the wavelength conversion layer **120**. Specifically, the use of perforations may enable the liquid insulating material to penetrate through or be injected in the perforations in order to fill a space between the substrate, the light emitting devices, and the wavelength conversion layer so as to avoid the formation of voids in the space. Details thereof will be provided in a process of forming the encapsulating part.

The wavelength conversion layer **120** may be formed by cutting the wavelength conversion sheet having the perforations formed therein, and may be disposed on the at least two light emitting devices having the same (or substantially similar) color characteristic values.

Next, as illustrated in FIG. **4**, an encapsulating part **130** may be further formed to cover the wavelength conversion layer **120**, thereby preventing contact with air and moisture. The encapsulating part **130** may be formed to enclose the light emitting devices **110** and the wavelength conversion layer **120**. The encapsulating part **130** may enclose the light emitting devices **110** and the wavelength conversion layer **120**, thereby protecting them from moisture and heat. The shape of the encapsulating part **130** may be adjusted to thereby control the distribution of light emitted from the light emitting devices **110**.

The encapsulating part **130** may be formed of a light transmissive insulating material, and specifically, a liquid insulating resin that is light transmissive, such as a silicone resin, a modified silicone resin, an epoxy resin, a urethane resin, an oxetane resin, an acrylic resin, a polycarbonate resin, a polyimide resin, and a combination thereof. However, the material of the encapsulating part is not limited thereto, and an inorganic material having excellent light transmittance, such as glass, silica gel, or the like, may also be used therefor.

In a case in which the perforations are not formed in the wavelength conversion layer **120** at the time of forming the encapsulating part **130**, the liquid insulating material may not be injected between the light emitting devices **110**, resulting in the formation of voids. In a case in which the voids are formed between the light emitting devices **110**, the rate of occurrence of packaging defects in a process of separating the light emitting devices **110** from one another may be increased, resulting in an increase in product defect rate. According to the present exemplary embodiment, the liquid insulating material may be injected through the slits **121** and the holes **122** in the wavelength conversion layer **120**, thereby preventing voids from being formed between the light emitting devices **110**. Thus, the product defect rate may be significantly lowered.

Next, as illustrated in FIG. **5**, the encapsulating part **130** and the package substrate **101** may be cut and divided into individual light emitting device packages **100** using a blade E. However, a division method of the light emitting device packages **100** is not limited thereto, and a division method relying on irradiation of a laser beam or the like may be used.

Next, a method of manufacturing light emitting device packages according to an exemplary embodiment in the present disclosure will be described below. FIGS. **6** through **11** are schematic views illustrating a method of manufacturing light emitting device packages according to an exemplary embodiment in the present disclosure.

The present exemplary embodiment differs from the previous exemplary embodiment in that, after a wavelength conversion layer having a uniform thickness is formed on the entire surface of a package substrate on which light emitting devices are disposed, an additional wavelength conversion layer may be selectively formed according to the color characteristics of individual light emitting devices. The present exemplary embodiment will be described on the basis of this difference.

First, a plurality of light emitting devices **210** may be formed by growing a plurality of semiconductor layers on a wafer as in the previous exemplary embodiment. Next, the color characteristics of the plurality of light emitting devices **210** may be measured.

The plurality of light emitting devices **210** may be disposed above a package substrate **201** at predetermined intervals, as illustrated in FIG. **6**.

The measured color characteristics may be at least one of wavelength (e.g., wavelength range and intensity spectrum), power, full width at half maximum (FWHM), and color coordinates of light emitted from the light emitting devices **210**. According to the present exemplary embodiment, an average wavelength of light emitted from the light emitting devices **210** may be measured.

However, the measuring method is not limited thereto. Various methods for measuring the color characteristics, such as a method of irradiating ultraviolet light or a laser beam onto the surfaces of the light emitting devices **210** and measuring light reflected from the surfaces, may be used.

Then, as illustrated in FIG. **6**, a wavelength conversion layer **220** may be formed to coverall the plurality of light emitting devices **210** as a whole.

This operation refers to forming the wavelength conversion layer **220** having a uniform thickness on all of the light emitting devices **210** mounted on the package substrate **201**, instead of disposing different wavelength conversion layers **220** on individual light emitting devices **210** according to the color characteristics of the individual light emitting devices **210** as in the previous example described in relation to FIG. **3**. The wavelength conversion layer **220** may be formed to have a uniform thickness. At this time, a type and an amount of a wavelength conversion material required for color compensation of the light emitting devices **110** may be determined based on a difference between the previously measured color characteristics and color characteristics targeted in the manufacturing process (hereinafter, referred to as the "target color characteristics"). In a case in which all of the plurality of light emitting devices **210** satisfy target color characteristics, it may be determined that the wavelength conversion layer **220** is formed in a standard amount for converting the light emitted from the light emitting devices **210** into white light. At this time, the wavelength conversion layer **220** may be formed to decrease the necessity of forming an additional wavelength conversion layer **240** for satisfying the target color characteristics in a subsequent process. Therefore, the wavelength conversion layer **220** can be formed by setting the color characteristic value in light of the lowest necessity of forming the additional wavelength conversion layer **240** as the standard amount, on the basis of the previously measured color characteristic values. For example, the color characteristic value of the wavelength conversion layer **220** may be set based on the measured color characteristic value of the light emitting device(s) **210** requiring the lowest level of adjustment in order to satisfy the target color characteristic. In this way, the time required for forming the additional wavelength conversion layer **240** may be reduced.

Next, a type and an amount of a wavelength conversion material required for color compensation of each light emitting device **210** may be determined based on a difference between the previously measured color characteristics and the target color characteristics. At this time, the type and the amount of the wavelength conversion material required may be determined in consideration of the previously formed wavelength conversion layer **220** (e.g., by adjusting the determined color compensation of each light emitting device **210** based on the previously formed wavelength conversion layer **220** covering the device **210**).

Next, as illustrated in FIG. **7**, an align-key **230** used for disposing the additional wavelength conversion layer **240** in a subsequent process may be attached to the wavelength conversion layer **220**. The align-key **230** may be a thin sheet of which one surface is provided with marks **231** (e.g., regularly disposed marks arrayed on the align-key **230**), used as an array standard for selectively attaching the additional wavelength conversion layer **240** in a subsequent process. However, the attachment of the align-key is not essential, and may be omitted if the arrangement of the light emitting devices **210** positioned below the wavelength conversion layer **220** can be easily observed without the align-key, for example.

Next, as illustrated in FIG. **8**, considering the type and the amount of the wavelength conversion material determined in the previous operation, the additional wavelength conversion layer **240** may be selectively formed on the wavelength conversion layer **220** in a position corresponding to at least a portion of the plurality of the light emitting devices **210**.

At this time, the additional wavelength conversion layer **240** may be formed to cover at least two light emitting devices having the same color characteristic values among the plurality of light emitting devices **210** (e.g., two adjacent light emitting devices having the same color characteristic values), as in the previous exemplary embodiment, whereby the time required for disposing the additional wavelength conversion layer **240** may be shortened. The additional wavelength conversion layer **240** may further include a first region having a first type and a first amount of wavelength conversion material determined based on a measured color characteristic of one or more light emitting devices in one region of the substrate **201**, and a second region having a second type and a second amount of wavelength conversion material (different from the first type and first amount) determined based on a measured color characteristic of one or more light emitting devices in another region of the substrate **201**.

First and second bonding pads **202***a* and **202***b* may be formed on the package substrate **201**, and the light emitting devices **210** may be mounted on the first and second bonding pads **202***a* and **202***b*. First and second electrodes **214***a* and **214***b* of the light emitting devices **210** may be electrically connected to the first and second bonding pads **202***a* and **202***b* using a conductive adhesive such as solder bumps or the like. The light emitting devices **210** may be mounted above one surface of the package substrate **201**, and first and second through electrodes **203***a* and **203***b* may penetrate through the package substrate **201** from one surface of the package substrate **201** to the other surface thereof in a thickness direction. The first and second bonding pads **202***a* and **202***b* may be disposed on one surface and the other surface of the package substrate **201** (e.g., the opposing surface) to which the ends of the first and second through electrodes **203***a* and **203***b* are exposed, such that both surfaces of the package substrate **201** may be electrically connected to each other. The package substrate **201** may be a substrate for manufacturing wafer level packages (WLPs) in which packages are completely formed on the wafer level.

FIG. **9** is a side cross-sectional view taken along line D-D' of FIG. **8**, and illustrates that the wavelength conversion layer **220** is formed on the light emitting devices **210** and the align-key **230** provided with the marks **231** is disposed thereon. In addition, the marks **231** may be disposed to correspond to and align with regions ISO between the plurality of light emitting devices **210**, thereby marking positions for guiding the placement of additional wavelength conversion layers **240***b*, **240***c*, and **240***d*. As noted above, different light emitting devices **210** may have different wavelength conversion layers **240***b*, **240***c*, and **240***d* disposed thereon depending on the measured color characteristics of the different light emitting devices **210**. In some embodiments, at least some of the light emitting devices **210** will not have any additional wavelength conversion layer formed thereon.

Next, as illustrated in FIG. **10**, an encapsulating part **250** may be further formed to cover the wavelength conversion layer **220** and the additional wavelength conversion layer **240** (including wavelength conversion layers **240***b*, **240***c*, and **240***d*), thereby preventing air and moisture contact. Prior to the forming of the encapsulating part **250**, the wavelength conversion layer **220** and the additional wavelength conversion layer **240** may be cut and divided into individual light emitting devices **210** with reference to the marks **231** of the align-key **230**.

Next, as illustrated in FIG. **11**, the encapsulating part **250** and the package substrate **201** may be cut and divided into individual light emitting device packages **200** using a blade E. However, a division method of the light emitting device packages **200** is not limited thereto, and a division method through irradiation of a laser beam or the like may be used.

The light emitting device packages according to exemplary embodiments in the present disclosure may be usefully applied to various products.

FIGS. **12** and **13** illustrate examples of a backlight unit to which a light emitting device package according to an exemplary embodiment in the present disclosure is applied.

With reference to FIG. **12**, a backlight unit **1000** may include at least one light source **1001** mounted on a substrate **1002** and at least one optical sheet **1003** disposed thereabove. The light emitting device packages according to the above-described exemplary embodiments may be used as the light source **1001**.

The light source **1001** in the backlight unit **1000** of FIG. **12** emits light toward a liquid crystal display (LCD) device disposed thereabove, whereas a light source **2001** mounted on a substrate **2002** in a backlight unit **2000** according to another embodiment illustrated in FIG. **13** emits light laterally, and the light is incident to a light guide plate **2003** such that the backlight unit **2000** may serve as a surface light source. The light travelling to the light guide plate **2003** may be emitted upwardly and a reflective layer **2004** may be disposed below a lower surface of the light guide plate **2003** in order to improve light extraction efficiency.

FIG. **14** is an exploded perspective view illustrating an example of a lighting device to which a light emitting device package according to an exemplary embodiment in the present disclosure is applied.

A lighting device **3000** illustrated in FIG. **14** is a bulb-type lamp by way of example, and includes a light emitting module **3003**, a driver **3008**, and an external connector **3010**.

In addition, the lighting device **3000** may further include exterior structures such as external and internal housings **3006** and **3009**, a cover **3007**, and the like. The light emitting module **3003** may include a light source **3001** and a circuit board **3002** on which the light source **3001** is mounted. The light emitting device packages according to the above-described exemplary embodiments may be used as the light source **3001**. For example, the first and second electrodes of the above-described light emitting device package may be electrically connected to electrode patterns of the circuit board **3002**. In the present exemplary embodiment, a single light source **3001** is mounted on the circuit board **3002** by way of example; however, a plurality of light sources may be mounted thereon as necessary.

The external housing **3006** may serve as a heat radiator and may include a heat sink plate **3004** directly contacting the light emitting module **3003** to thereby improve heat dissipation and heat radiating fins **3005** surrounding a lateral surface of the lighting device **3000** to further improve heat dissipation. The cover **3007** may be disposed above the light emitting module **3003** and have a convex lens shape. The driver **3008** may be disposed inside the internal housing **3009** and be connected to the external connector **3010** such as a socket structure to receive power from an external power source. In addition, the driver **3008** may convert the received power into power appropriate for driving the light source **3001** of the light emitting module **3003** and supply the converted power thereto. For example, the driver **3008** may be provided as an AC-DC converter, a rectifying circuit part, or the like.

FIG. **15** illustrates an example of a headlamp to which a light emitting device package according to an exemplary embodiment in the present disclosure is applied.

With reference to FIG. **15**, a headlamp **4000** used in a vehicle or the like may include a light source **4001**, a reflector **4005**, and a lens cover **4004**, and the lens cover **4004** may include a hollow guide part **4003** and a lens **4002**. The light emitting device packages according to the above-described exemplary embodiments may be used as the light source **4001**.

The headlamp **4000** may further include a heat radiator **4012** dissipating heat generated by the light source **4001** outwardly. The heat radiator **4012** may include a heat sink **4010** and a cooling fan **4011** in order to effectively dissipate heat. In addition, the headlamp **4000** may further include a housing **4009** allowing the heat radiator **4012** and the reflector **4005** to be fixed thereto and supported thereby. The housing **4009** may include a body **4006** and a central hole **4008** formed in one surface thereof, to which the heat radiator **4012** is coupled.

The housing **4009** may include a forwardly open hole **4007** formed in the other surface thereof integrally connected to one surface thereof and bent in a direction perpendicular thereto. The reflector **4005** may be fixed to the housing **4009**, such that light generated by the light source **4001** may be reflected by the reflector **4005**, pass through the forwardly open hole **4007**, and be emitted outwardly.

As set forth above, in a method of manufacturing light emitting device packages according to exemplary embodiments in the present disclosure, time required for forming a wavelength conversion layer is shortened, whereby manufacturing time of light emitting device packages may be reduced.

While exemplary embodiments have been shown and described above, it will be apparent to those skilled in the art that modifications and variations could be made without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of manufacturing a light emitting device package, the method comprising:

forming a plurality of light emitting devices by growing a plurality of semiconductor layers on a wafer;

measuring color characteristics of light emitted from each of the plurality of light emitting devices;

determining, for each of the plurality of light emitting devices, a type and an amount of wavelength conversion material for color compensating the light emitting device based on a difference between the measured color characteristics and target color characteristics;

forming, on at least two light emitting devices among the plurality of light emitting devices, a wavelength conversion layer having the type and the amount of wavelength conversion material determined for the at least two light emitting devices; and

dividing the plurality of light emitting devices into individual light emitting device packages,

wherein the forming of the wavelength conversion layer comprises:

preparing a wavelength conversion film having the type and the amount of the wavelength conversion material determined for the at least two light emitting devices;

cutting the wavelength conversion film to have an area sufficient to cover the at least two light emitting devices; and

disposing the cut wavelength conversion film on the at least two light emitting devices.

2. The method of claim **1**, wherein the wavelength conversion film is divided into a plurality of regions.

3. The method of claim **2**, wherein areas of the plurality of regions correspond to areas of the individual light emitting devices.

4. The method of claim **2**, wherein perforations are formed in the wavelength conversion film between the plurality of regions.

5. The method of claim **4**, wherein the perforations are slits.

6. The method of claim **1**, further comprising:

cutting the plurality of light emitting devices into individual light emitting devices and mounting the plurality of light emitting devices on a package substrate, prior to forming the wavelength conversion layer,

wherein the dividing into the individual light emitting device packages includes dicing the package substrate.

7. The method of claim **1**, further comprising:

forming a light transmissive encapsulating part on the plurality of light emitting devices on which the wavelength conversion layer has been formed, prior to dividing the plurality of light emitting devices into the individual light emitting device packages.

8. The method of claim **7**,

wherein the forming of the wavelength conversion layer comprises disposing on at least two light emitting devices a wavelength conversion film having the type and the amount of the wavelength conversion material determined for the at least two light emitting devices,

wherein perforations are formed in the wavelength conversion film, and

wherein the forming of the encapsulating part comprises injecting an insulating material for the encapsulating part into the perforations.

9. The method of claim **1**, wherein the wavelength conversion film is formed of a semi-cured material containing a phosphor.

10. The method of claim **1**, wherein the measured color characteristics of light emitted from each of the plurality of light emitting devices include at least one of wavelength, power, full width at half maximum (FWHM), and color coordinates of light emitted from each of the plurality of light emitting devices.

11. The method of claim **1**, wherein the wavelength conversion film has a structure in which a plurality of layers is stacked.

12. The method of claim **11**, wherein different layers of the plurality of layers in the wavelength conversion film include different phosphors.

13. The method of claim 1, further comprising:

forming a wavelength conversion cover layer having a uniform thickness to cover all of the plurality of light emitting devices.

14. A method comprising:

measuring, for each of a plurality of light emitting devices mounted on a substrate, color characteristics of light emitted from the light emitting device;

identifying, among the plurality of light emitting devices, a group of adjacent light emitting devices having similar measured color characteristics;

determining, for the group of adjacent light emitting devices, a type and an amount of wavelength conversion material for color compensating the light emitting devices based on a difference between the measured color characteristics and target color characteristics; and

disposing, across the group of adjacent light emitting devices, a wavelength conversion film having the type and the amount of wavelength conversion material determined for the group of light emitting devices,

wherein the wavelength conversion film spans across regions of the substrate between the adjacent light emitting devices, and

wherein the wavelength conversion film includes perforations formed in the wavelength conversion film in the regions spanning between the adjacent light emitting devices.

15. The method of claim 14, further comprising:

forming a light transmissive encapsulating part on the plurality of light emitting devices,

wherein the forming of the light transmissive encapsulating part includes injecting an insulating material for the encapsulating part into the perforations.

16. The method of claim 14,

wherein the identifying comprises identifying a first region of the substrate having a first group of adjacent light emitting devices disposed thereon having similar first measured color characteristics, and a second region of the substrate having a second group of adjacent light emitting devices disposed thereon having similar second measured color characteristics different from the first measured color characteristics,

wherein the determining comprises determining first and second types and first and second amounts of wavelength conversion material for color compensating the light emitting devices of the first and second groups, respectively, based on differences between the measured color characteristics and target color characteristics, and

wherein the disposing comprises disposing, across the first region of the substrate having the first group of adjacent light emitting devices disposed thereon, a first wavelength conversion film having the first type and the first amount of wavelength conversion material determined for the first group of light emitting devices, and disposing, across the second region of the substrate having the second group of adjacent light emitting devices disposed thereon, a second wavelength conversion film having the second type and the second amount of wavelength conversion material determined for the second group of light emitting devices.

17. The method of claim 16, further comprising:

forming a light transmissive encapsulating part on the plurality of light emitting devices and in regions between the light emitting devices of the first and second groups.

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